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Benfield et al.
**Method and system for restricting and enhancing topology displays
for multi-customer logical networks within a network management system**

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FIG. 1
(PRIOR ART)

FIG. 2A

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FIG. 2B

FIG. 2C

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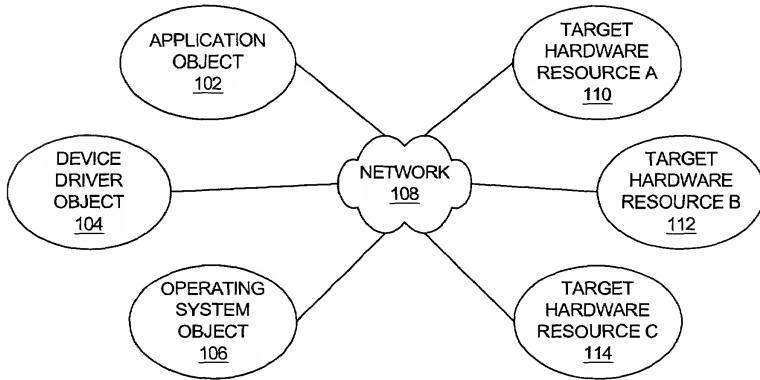for multi-customer logical networks within a network management system

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BRANCH OFFICE
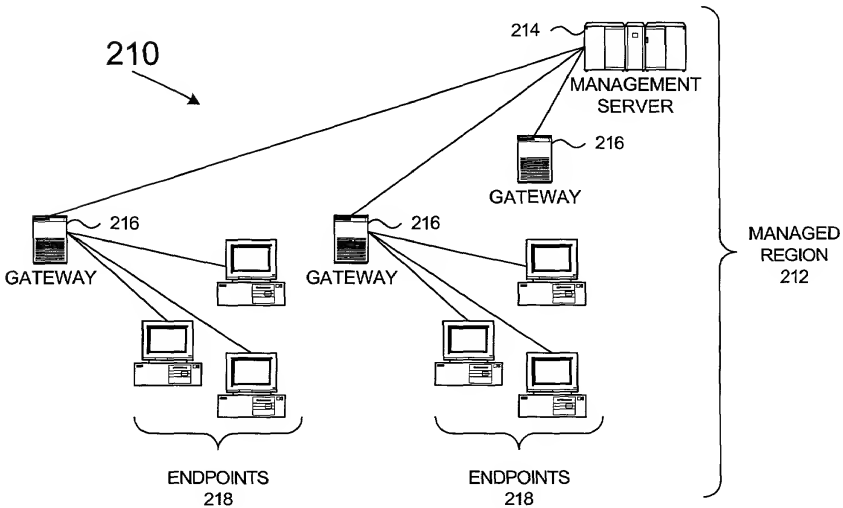238

CENTRAL OFFICE
240

BRANCH OFFICE
239

ENDPOINT A
230

APPLICATION ACTION OBJECT
232

OPERATING SYSTEM OBJECT
236

DEVICE DRIVER OBJECT
234

ENDPOINT B
231

APPLICATION OBJECT
233

OPERATING SYSTEM OBJECT
237

DEVICE DRIVER OBJECT
235

FIG. 2D

FIG. 2E

ENDPOINT A
252

APPLICATION STACK
254

DISTRIBUTED KERNEL SERVICES/JVM
255

OPERATING SYSTEM RESOURCES
256

NETWORK DEVICE DRIVERS
257

NIC
258

ENDPOINT B
253

APPLICATION STACK
254

DISTRIBUTED KERNEL SERVICES/JVM
255

OPERATING SYSTEM RESOURCES
256

NETWORK DEVICE DRIVERS
257

NIC
258

NETWORK
250

DISTRIBUTED KERNEL SERVICES (DKS) GATEWAY
251

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FIG. 2F

FIG. 2G

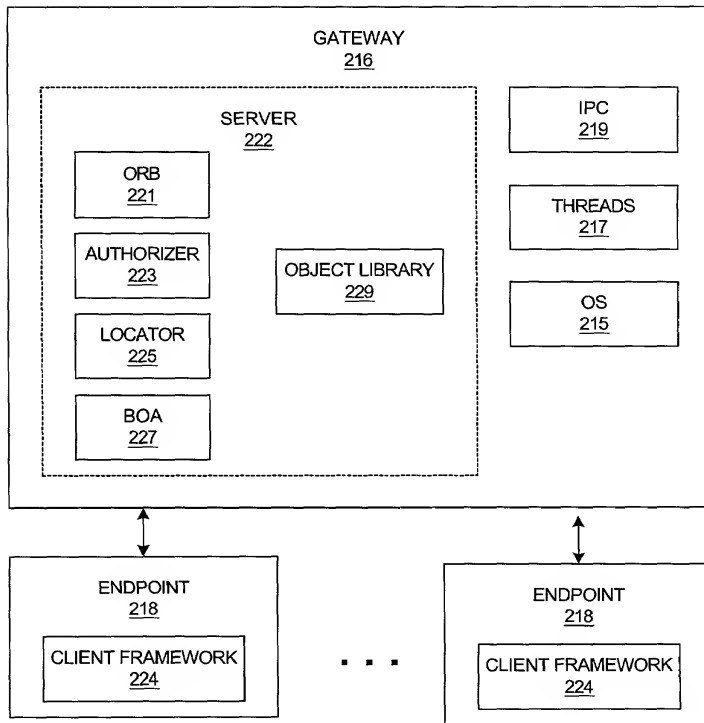**Atty. Docket # AUS920010376US1**
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ENDPOINT A 301	GATEWAY 300	ENDPOINT B 302
DKS ORB (ENDPOINT A) 320		**DKS ORB (ENDPOINT B)** 322
DKS APPLICATION (RESOURCE REQUESTER) 324	**ORB (DKS SERVICES)** 304 **NETWORK ENDPOINT LOCATION (NELS) SERVICE** 306	**TARGET RESOURCE (RESOURCE PROVIDER, OBJECT, OR APP)** 326
DKS SERVICES-- ENDPOINT 330	**IP OBJECT PERSISTENCE (IPOP) SERVICE** 308 **GATEWAY SERVICES** 310	**DKS SERVICES-- ENDPOINT** 334

FIG. 3

IP OBJECT PERSISTENCE (IPOP) SERVICE DATABASE 402	ENDPOINT DB TABLE 404	SYSTEM DB TABLE 406	NETWORK DB TABLE 408
	TOPO OBJECT	TOPO OBJECT	TOPO OBJECT
	⋮	⋮	⋮
	TOPO OBJECT	TOPO OBJECT	TOPO OBJECT

FIG. 4

Atty. Docket # AUS920010376US1
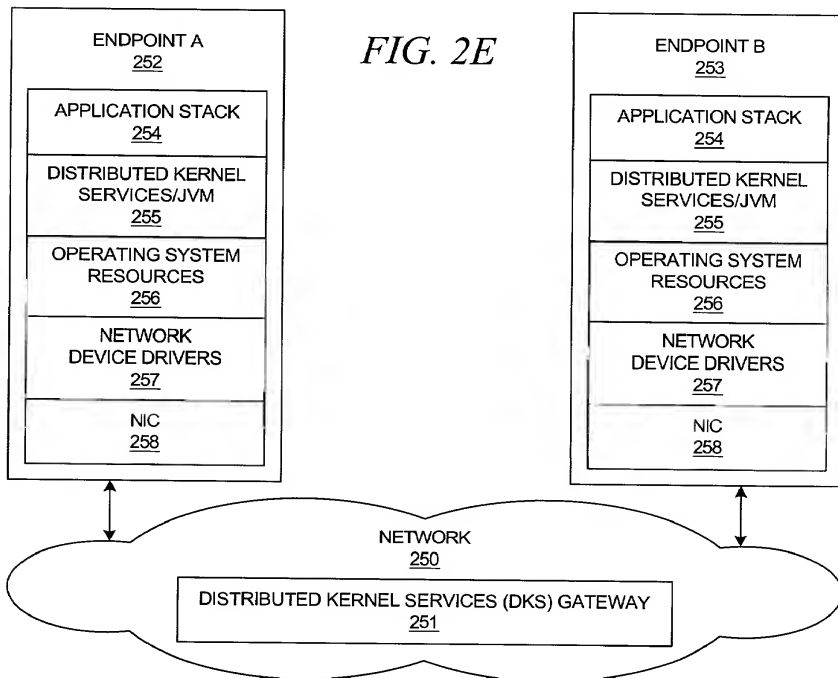Benfield et al.
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500

PHYSICAL IP NETWORKS
514

IP DRIVER
502

NETWORK
EVENT
MANAGER
APPLICATION
522

MONITOR
CONTROLLER
516

DISCOVERY
CONTROLLER
506

CONFIGURATION
SERVICE
528

IP DRIVER
CONTROLLER
530

IP DATA
CACHE
520

APPLICATION/
USERS
524

IP DRIVER
INTERFACE
526

IP MAPPER
508

TOPOLOGY
SERVICE
504

IP
DATASTORE
518

IP OBJECT
PERSISTENCE
(IPOP)
SERVICE
510

IPOP
DATABASE
512

FIG. 5A

DRIVER 1 SCOPE (D1)

1.2.11.22

1.2.11.0

ROUTER

DRIVER 2 SCOPE (D2)

1.2.12.0

1.2.12.22

1.2.14.22

1.2.13.22

1.2.13.0

1.2.14.0

DRIVER 3 SCOPE (D3)
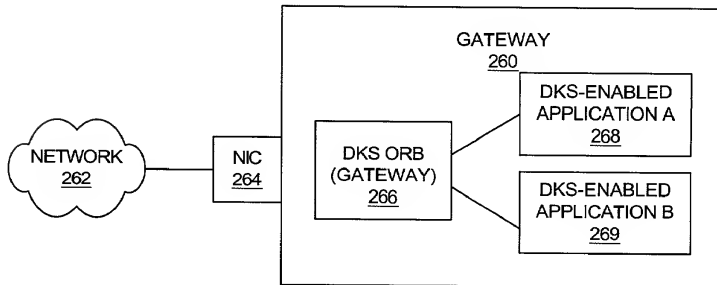
FIG. 5B

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FIG. 5C

FIG. 6
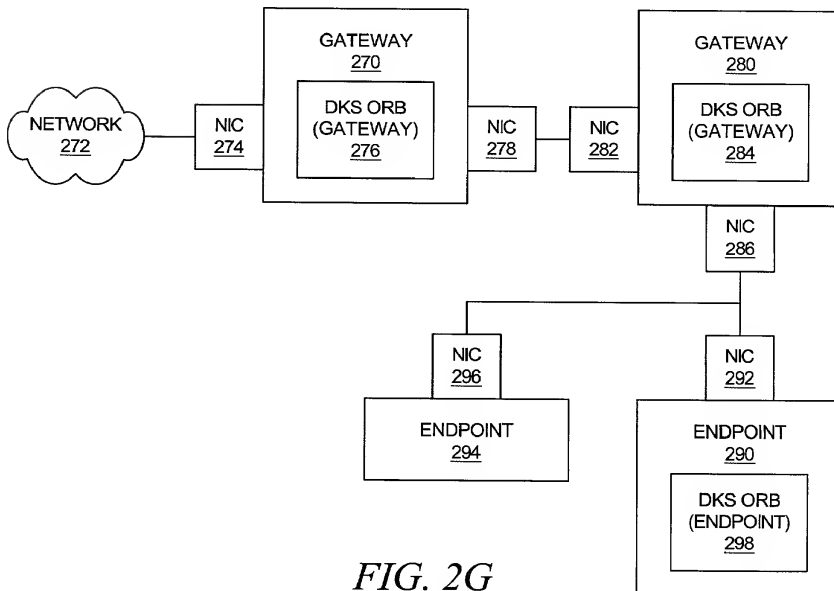
Atty. Docket # AUS920010376US1
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BEGIN

DISCOVERY ENGINE PERFORMS
DISCOVERY PROCESS ON
NETWORK AFTER
CONFIGURATION OF NETWORK
BY ADMINISTRATOR
702

DSC CREATOR
GENERATES DSC OBJECTS
704

SOURCE USER PERFORMS
LOGIN ON SOURCE EP
706

SECURITY SUBSYSTEM
UPDATES ACTIVE USER
DATABASE FOR ORB
708

END

FIG. 7A

BEGIN

FETCH ENDPOINT DATA FROM
IPOP
710

FETCH USER DATA FROM
ALL-USER DATABASE
IN SECURITY SUBSYSTEM
712

FETCH DSC CONFIGURATION
DATA FROM CONFIGURATION
SERVICE DATABASE
714

CREATE DSC OBJECTS
FOR ALL USERS
716

CREATE DSC OBJECTS
FOR ALL ENDPOINTS
718

END

FIG. 7B

Atty. Docket # AUS920010376US1
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Method and system for restricting and enhancing topology displays
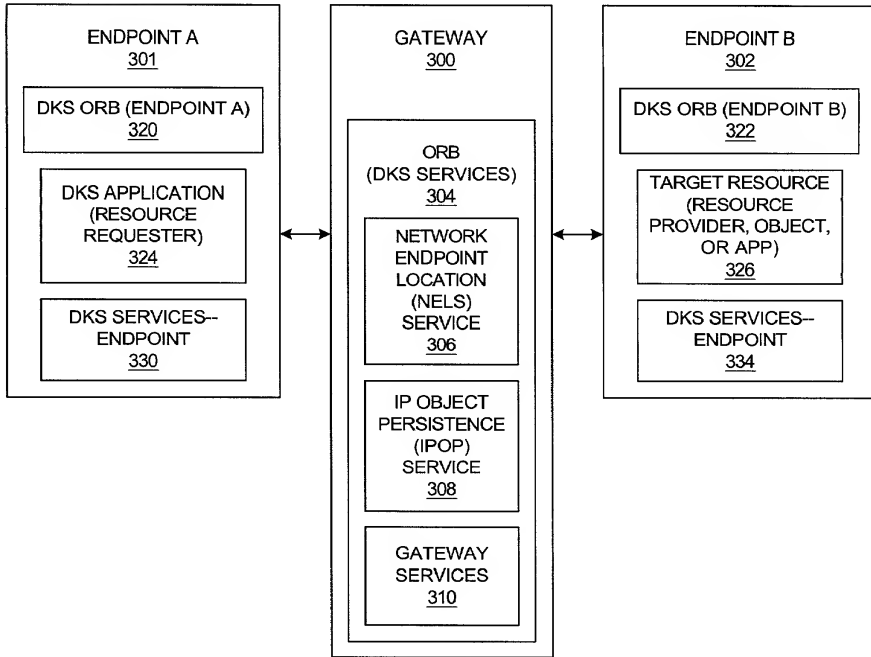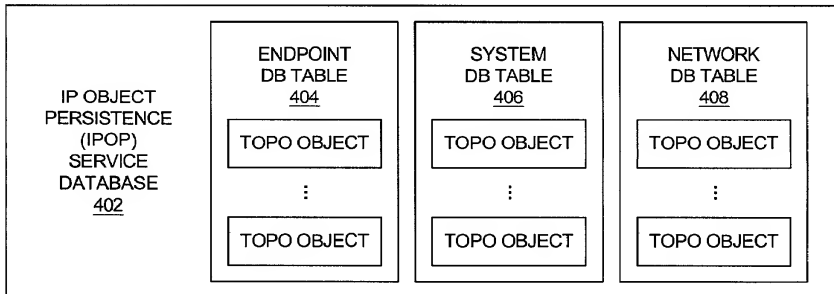**for multi-customer logical networks within a network management system**

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FIG. 7C

BEGIN

READ SCOPE DATA FOR
TARGET ENDPOINT FROM IPOP
720

READ SCOPE DATA FOR
SOURCE USER
FROM IPOP
722

IS
SOURCE
USER ALLOWED
ACCESS TO TARGET
ENDPOINT?
724 — NO

YES

CREATE DSC FOR CURRENT
USER/ENDPOINT COMBINATION
726

STORE CREATED DSC OBJECT
IN DSC DATABASE
728

MORE
USERS TO PROCESS?
729 — YES

NO

END

FIG. 7C

FIG. 7D

BEGIN

READ SCOPE DATA FOR
TARGET ENDPOINT FROM IPOP
730

READ SCOPE DATA FOR
SOURCE ENDPOINT
FROM IPOP
732

DOES
SOURCE ENDPOINT
HAVE ACCESS TO TARGET
ENDPOINT?
734 — NO

YES

CREATE DSC FOR SOURCE
ENDPOINT/TARGET ENDPOINT
COMBINATION
736

STORE CREATED DSC OBJECT
IN DSC DATABASE
738

MORE ENDPOINTS TO
PROCESS?
739 — YES

NO

END

FIG. 7D

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Method and system for restricting and enhancing topology displays
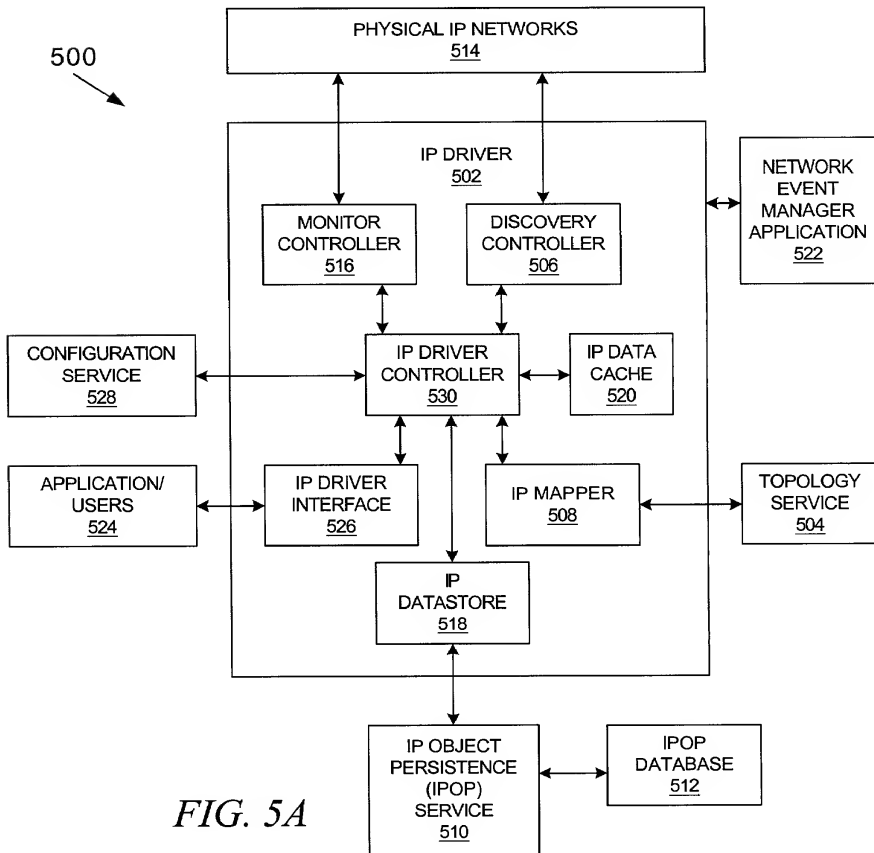for multi-customer logical networks within a network management system

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BEGIN

DISCOVERY ENGINE SCANS PHYSICAL
NETWORK UNTIL NEW DEVICE IS FOUND
802

DOES NETWORK EXIST?
804

NO → CREATE PHYSICAL
NETWORK OBJECT
806

YES

DOES SYSTEM EXIST?
808

NO → CREATE PHYSICAL
SYSTEM OBJECT
810

YES

CREATE PHYSICAL ENDPOINT OBJECT FOR
DISCOVERED DEVICE
812

STORE CREATED OBJECTS INTO IPOP DB
814

MAP CREATED OBJECTS INTO TOPOLOGY
816

CREATE TOPOLOGY OBJECTS
818

STORE TOPOLOGY OBJECTS INTO
TOPOLOGY DATABASE
820

END

FIG. 8A

900

Topology Console Application ▭▱⊠

908
R1
902 ~ ROUTER1 ⟨ ENDPOINT1 ⟩~ 904

⟨ ENDPOINT2 ⟩~ 906
R2
910

OK

FIG. 9A

Atty. Docket # AUS920010376US1
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Method and system for restricting and enhancing topology displays
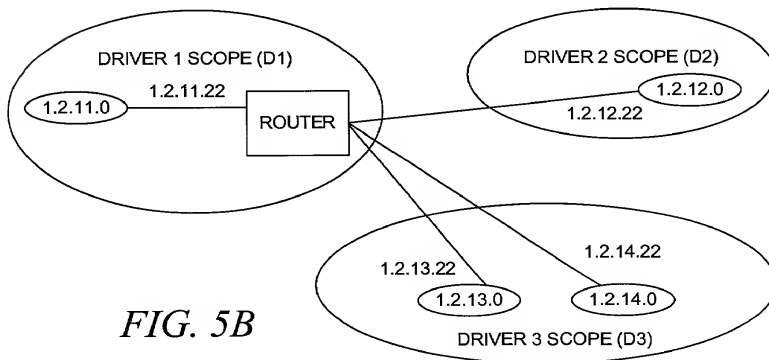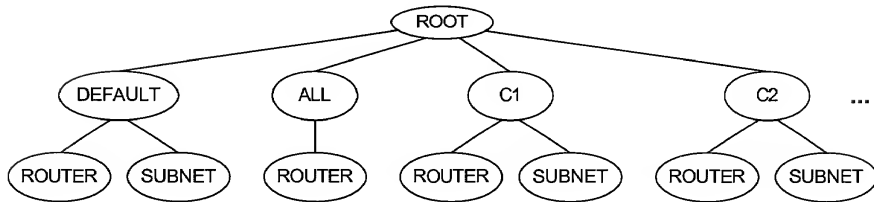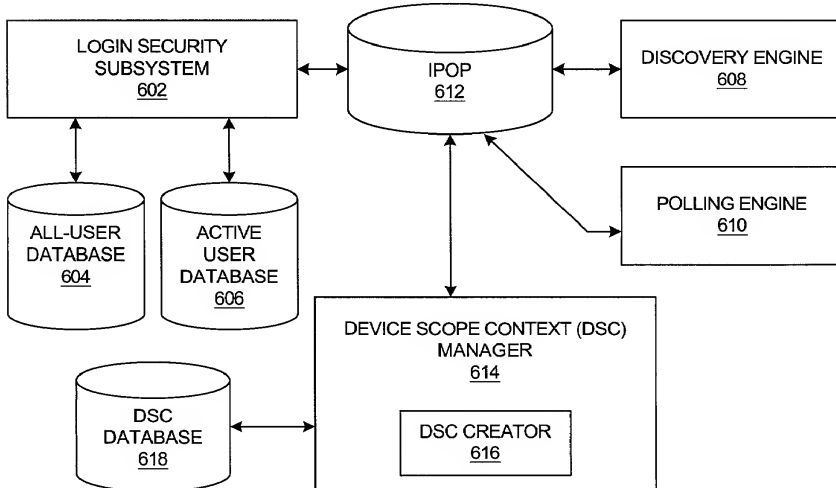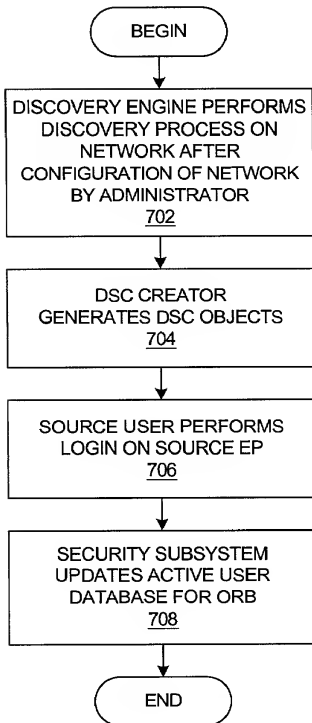**for multi-customer logical networks within a network management system**

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```
                        ┌─────────┐
                        │  BEGIN  │
                        └─────────┘
                             │
                             ▼
        ╱────────────────────────╲          ╱──────────────────────╲
       ╱        FAILED             ╲        ╱         NEW            ╲
      ╱  SYSTEM FOUND BY POLLING?   ╲──NO──▶  DEVICE DISCOVERED?      ╲──NO──┐
      ╲           832              ╱        ╲          834           ╱       │
       ╲                          ╱          ╲                      ╱        │
        ╲────────────────────────╱            ╲────────────────────╱         │
                  │ YES                                 │ YES                │
                  ▼                                     │                    │
        ┌──────────────────────────┐                   │                    │
        │  UPDATE IPOP DATABASE     │◀──────────────────┘                    │
        │          836              │                                        │
        └──────────────────────────┘                                        │
                  │                                                          │
                  ▼                                                          │
        ╱────────────────────────╲                                          │
       ╱        DOES               ╲                                         │
      ╱  CHANGE AFFECT TOPOLOGY?    ╲──NO──────────────────────────┐         │
      ╲           838              ╱                               │         │
       ╲                          ╱                                │         │
        ╲────────────────────────╱                                │         │
                  │ YES                                            │         │
                  ▼                                                │         │
        ┌──────────────────────────────┐                          │         │
        │ UPDATE  CURRENT TOPOLOGY      │                          │         │
        │ DATABASE  840                 │                          │         │
        └──────────────────────────────┘                          │         │
                  │                                                │         │
                  ▼◀───────────────────────────────────────────────         │
        ┌─────────┐                                                          │
        │   END   │                                                          │
        └─────────┘                                                          │
```

FIG. 8B

930

Topology Console Application	▢◰⊠

ROUTER1 — 932

936 R1 ENDPOINT1 — 934
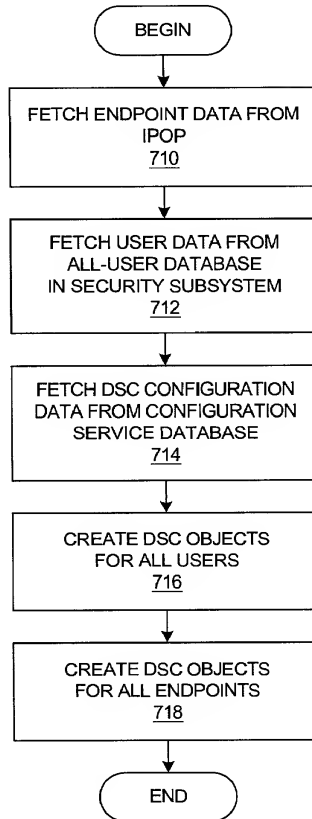
OK

FIG. 9B

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Method and system for restricting and enhancing topology displays
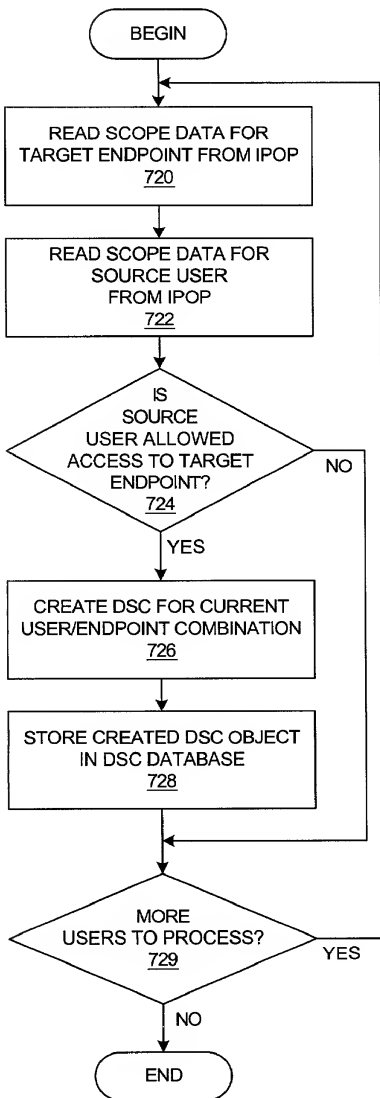for multi-customer logical networks within a network management system

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EXTERNAL
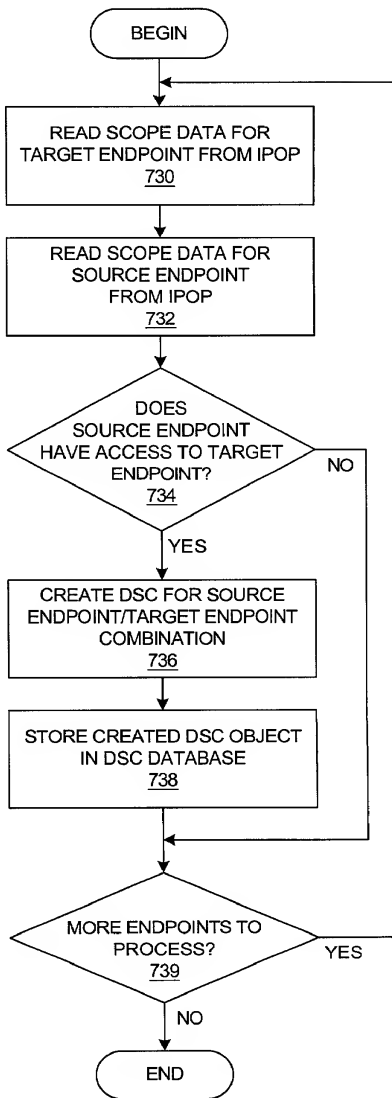NETWORK
1022

OUTER
NIC
1026

FIREWALL/NETWORK ADDRESS
TRANSLATOR (NAT)
1020

INNER
NIC
1028

SYSTEM A
1030

NIC
1032

INTERNAL PROTECTED
NETWORK
1024

NIC
1040

SYSTEM C
1038

(10.0.0.1)

(10.0.0.3)

NIC
1036

SYSTEM B
1034

(10.0.0.2)

FIG. 10A

(PRIOR ART)

MULTICUSTOMER DATABASE
1052

SERVICE
PROVIDER
1050

CUSTOMER A
1054

NAT
1058

SUBNET A
1056

CUSTOMER B
1064

NAT
1068

SUBNET Z
1066

FIG. 10B

Atty. Docket # AUS920010376US1
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Method and system for restricting and enhancing topology displays
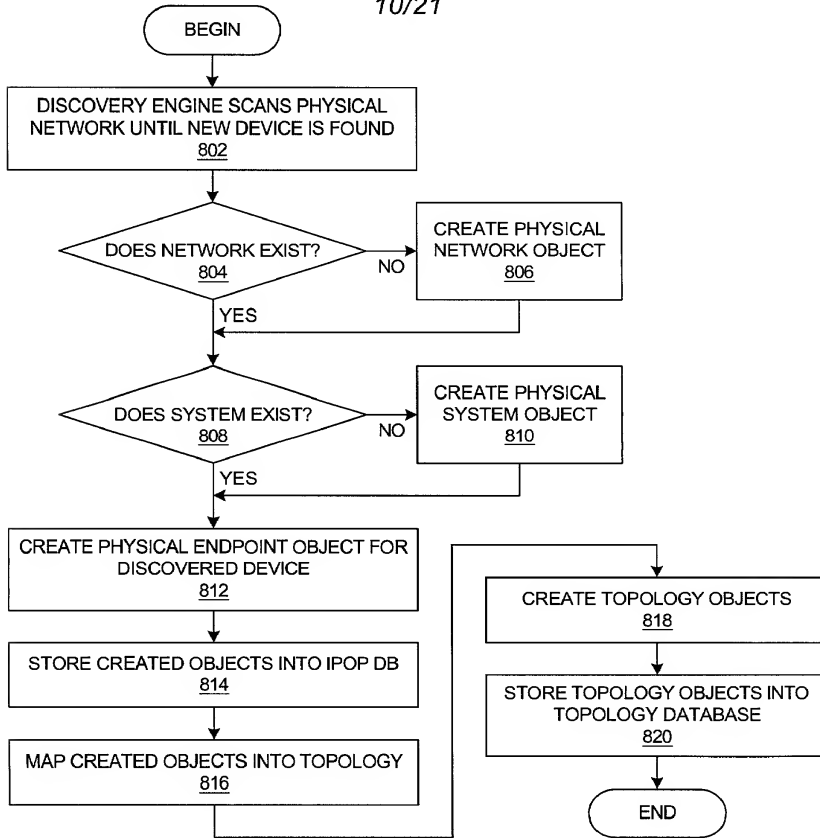for multi-customer logical networks within a network management system

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FIG. 11A

FIG. 13

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Benfield et al.
Method and system for restricting and enhancing topology displays
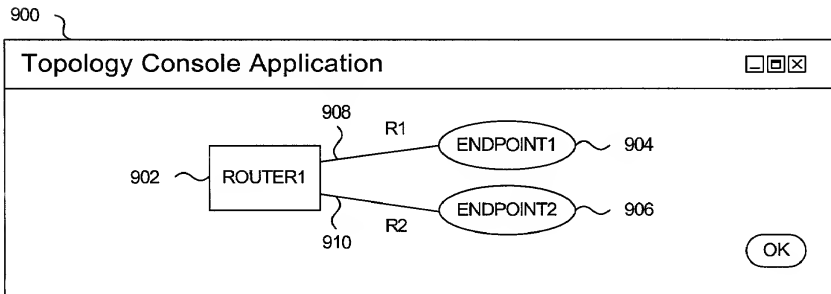**for multi-customer logical networks within a network management system**

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```
Public Class IPActionObject {

        Endpoint sourceEP;
        Endpoint targetEP;

        // CONSTRUCTOR
        IPActionObject( Endpoint targetEP, Endpoint sourceEP ) {
            .
            .
            .
        }
        VOID performAction( ) // EXECUTES ACTION METHOD
    .
    .
    .
}
```

FIG. 11B

```
Public Class Endpoint {

        // public variables
        long    EPObjectID;  // ID to object (both private and public network addresses)
        InetAddress  EPIPAddress;        // physical network address (private or public)
        long    EPVPN;       // virtual private network ID

        //get/set of variables
        public long            getObjectID( ) { ... }
        public InetAddress    getPAddress( ) { ... }
        public long            getVPN( ) { ... }

}
```

FIG. 11C

```
Public Class EndpointCustomer extends Endpoint {

        public getVPNGW( ) {
                //gets the only gateway which has access to a particular private network
                .
                .
                .
        }
        //private variables only set/accessed by EP creator IPOP
        long    customerHashNumber;
        String  customerName;
        String  customerAnchorPath;
        Long    objectIoFPrivateGatewayRoute

}
```

FIG. 11D

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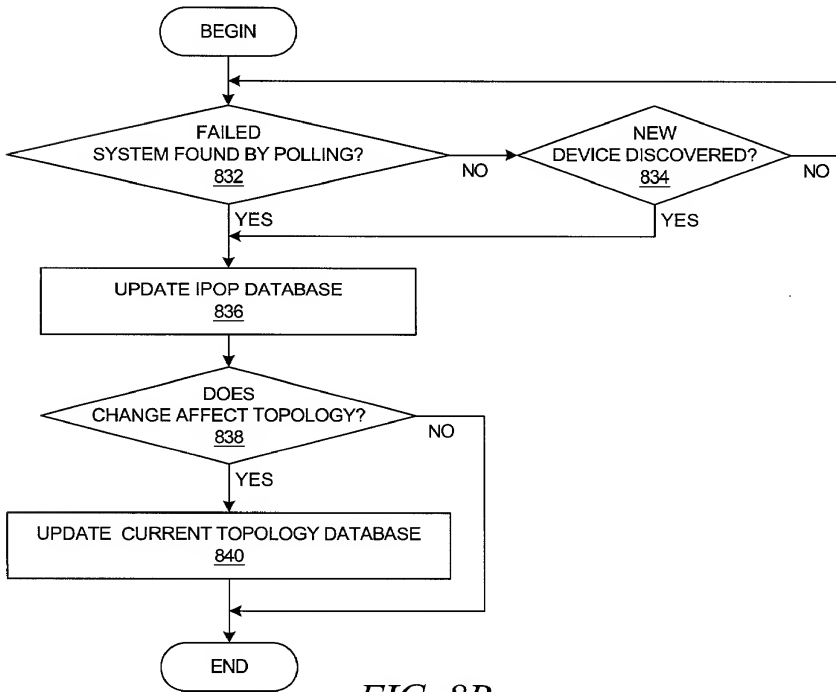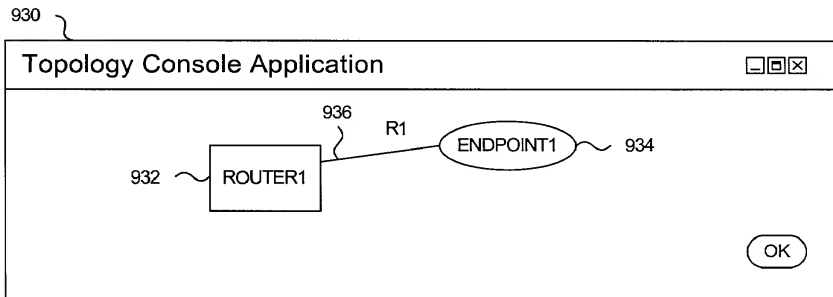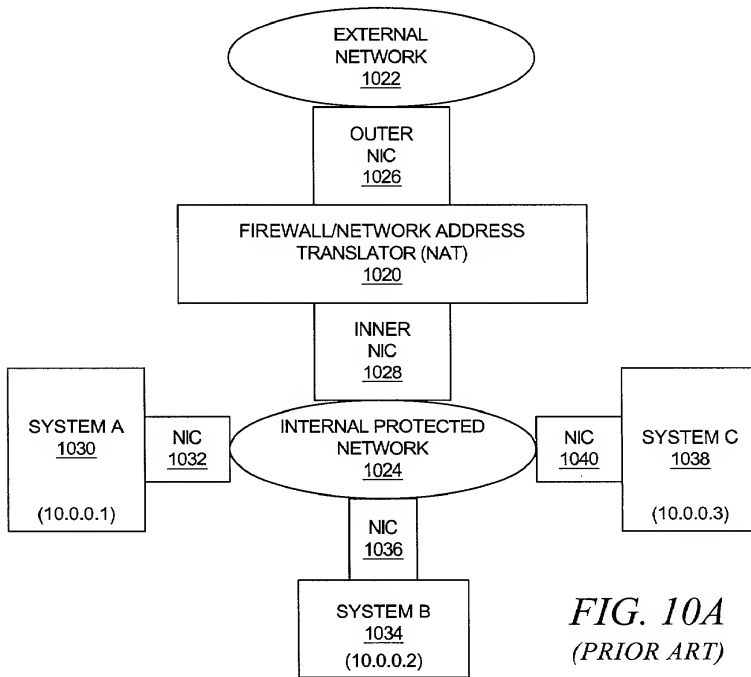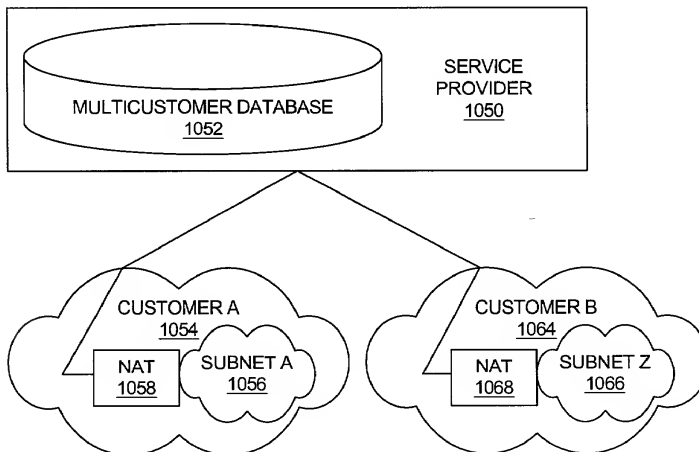**for multi-customer logical networks within a network management system**

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FIG. 12A

```
                    ┌─────────┐
                    │  BEGIN  │
                    └─────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │   MULTI-CUSTOMER ADMINISTRATOR         │
    │       CREATES DKS VPN IDs              │
    │               1202                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │   MULTI-CUSTOMER ADMINISTRATOR         │
    │   CREATES NETWORK SCOPE FOR ALL        │
    │             CUSTOMERS                  │
    │               1204                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │   ADMINISTRATOR RESOLVES               │
    │   ADDRESSABILITY PROBLEMS              │
    │               1206                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │   STORE MAPPING OF CUSTOMERS,          │
    │  VPNs, CUSTOMER ANCHORNAMES, AND       │
    │       CUSTOMER NETWORKS                │
    │           IN IPOP DB                   │
    │               1208                     │
    └───────────────────────────────────────┘
                         │
                         ▼
                    ┌─────────┐
                    │   END   │
                    └─────────┘
```

FIG. 12A

FIG. 12B

```
                    ┌─────────┐
                    │  BEGIN  │
                    └─────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │           ORB STARTS                   │
    │   CUSTOMER ADDRESS MANAGER             │
    │               1212                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │   FIND IDENTITY OF ADMINISTRATOR       │
    │               1214                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │          RETRIEVE ALL                  │
    │   DISCOVERED NETWORKS FOR              │
    │  ADMINISTRATOR'S CUSTOMER OR           │
    │           CUSTOMERS                    │
    │               1216                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │  ASSIGN VPN IDs TO ALL NETWORKS        │
    │         NEEDING VPN                    │
    │               1218                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │  UPDATE NETWORK OBJECTS IN             │
    │  IPOP WITH ASSIGNED VPN IDs            │
    │               1220                     │
    └───────────────────────────────────────┘
                         │
                         ▼
    ┌───────────────────────────────────────┐
    │  UPDATE SCOPE CONFIGURATION            │
    │   WITH ASSIGNED VPN IDs                │
    │               1222                     │
    └───────────────────────────────────────┘
                         │
                         ▼
                    ┌─────────┐
                    │   END   │
                    └─────────┘
```

FIG. 12B

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```
                          ┌─────────────┐
                          │    BEGIN    │
                          └──────┬──────┘
                                 │
                                 ▼
                ┌──────────────────────────────────┐
                │  DISPLAY NETWORKS THAT NEED A     │
                │  VPN ID TO THE ADMINISTRATOR      │
                │              1232                 │
                └────────────────┬─────────────────┘
                                 │
                                 ▼
                ┌──────────────────────────────────┐
                │ DISPLAY POSSIBLE VPN IDs FROM WHICH│
                │   ADMINISTRATOR MAY CHOOSE        │
                │              1234                 │
                └────────────────┬─────────────────┘
                                 │
                                 ▼
                ┌──────────────────────────────────┐
                │ LET ADMINISTRATOR DEFINE VPN IDs IF│
                │    NOT ALREADY DEFINED            │
                │              1236                 │
                └────────────────┬─────────────────┘
                                 │
                                 ▼
                          ◇ IS
                          ADMINISTRATOR A
           NO ◄──────── MULTI-CUSTOMER ────────► YES
                          ADMINISTRATOR?
                          1238
```

ASSIGN VPN ID TO NETWORKS OF
ADMINISTRATOR'S CUSTOMER
1240

GET CUSTOMER FROM
ADMINISTRATOR
1242

ASSIGN VPN ID TO THE NETWORKS
OF THE SPECIFIED CUSTOMER OF
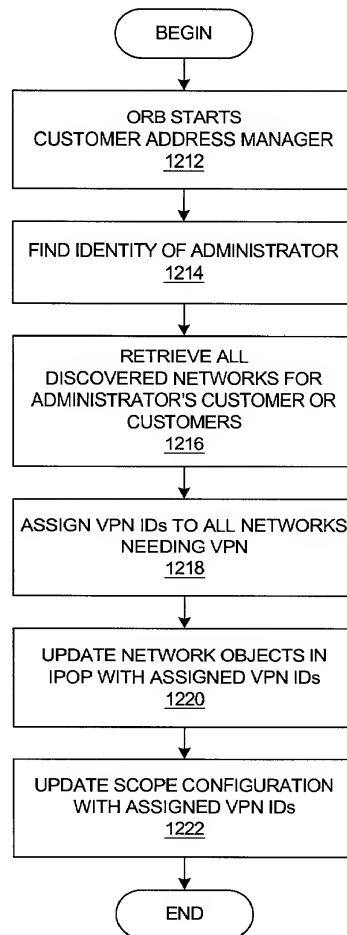THE ADMINISTRATOR
1244

END

FIG. 12C

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BEGIN

ORB STARTS PRIVATE NETWORK MULTI-CUSTOMER MANAGER (PNMCM)
1402

ADMINISTRATOR LAUNCHES APPLICATION/GUI THAT USES PNMCM
1404

ADMINISTRATOR CHOOSES AN ENDPOINT AND REQUESTS TO PERFORM AN IP PING ACTION
1406

PNMCM ATTEMPTS TO FETCH REQUESTED ENDPOINT FROM IPOP USING SPECIFIED IP ADDRESS ONLY
1408

DOES IPOP RETURN DUPLICATE ENDPOINTS?
1410

NO

YES

DISPLAY DUPLICATE ENDPOINTS AND ASSOCIATED VPN ID'S
1412

REQUEST ADMINISTRATOR TO CHOOSE ONLY ONE OF THE DUPLICATE ENDPOINTS
1414

ADMINISTRATOR REQUESTS IP PING ACTION ON SELECTED ENDPOINT
1416

PNMCM DISPLAYS RESULTS OF PING ACTION TO ADMINISTRATOR
1418

END

FIG. 14A

BEGIN

APPLICATION REQUESTS APPLICATION ACTION OBJECT OF TYPE "IP" (AAOIP) FOR TARGET ENDPOINT FROM GATEWAY
1422

GATEWAY ASKS NEL SERVICE TO DECODE TARGET ENDPOINT
1424

NEL SERVICE ASKS IPOP TO DECODE TARGET ENDPOINT
1426

IPOP DECODES ENDPOINT ADDRESS AND RETURNS GENERATED AAOIP INCLUDING VPN ID TO NEL
1428

NEL SERVICE RETURNS AAOIP TO GATEWAY
1430

GATEWAY RETURNS AAOIP TO APPLICATION
1432

APPLICATION PERFORMS DESIRED ACTION ("PING") ON TARGET ENDPOINT
1434
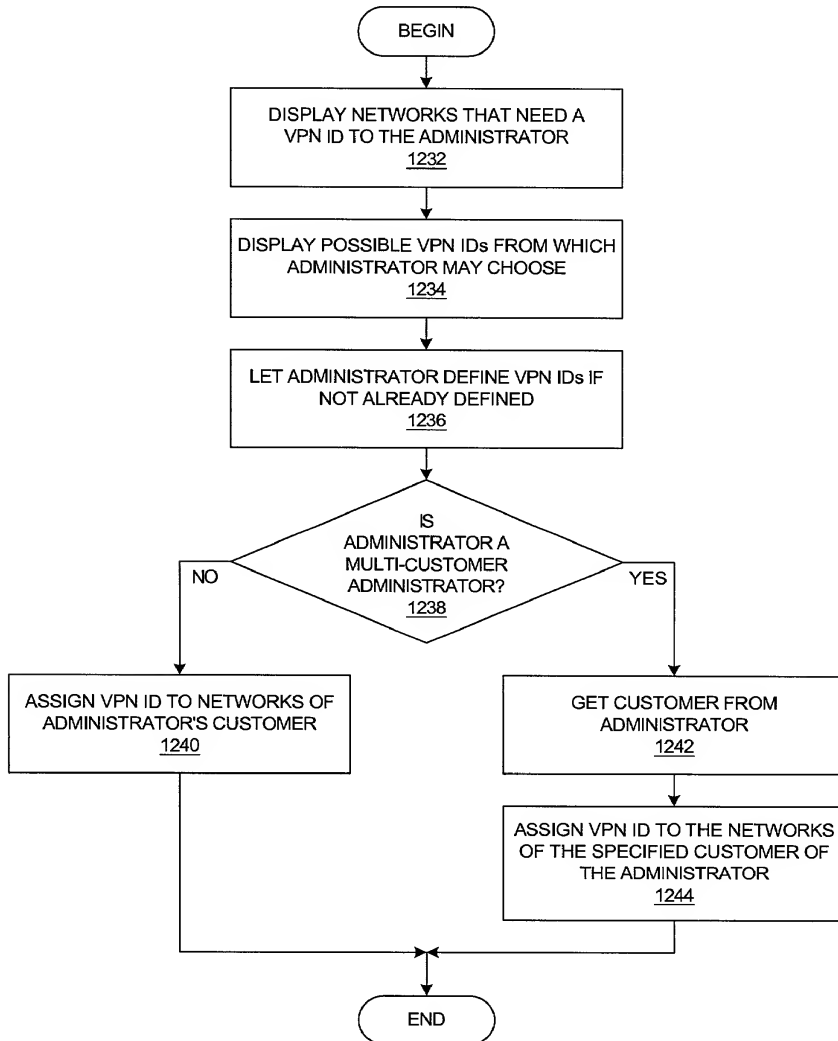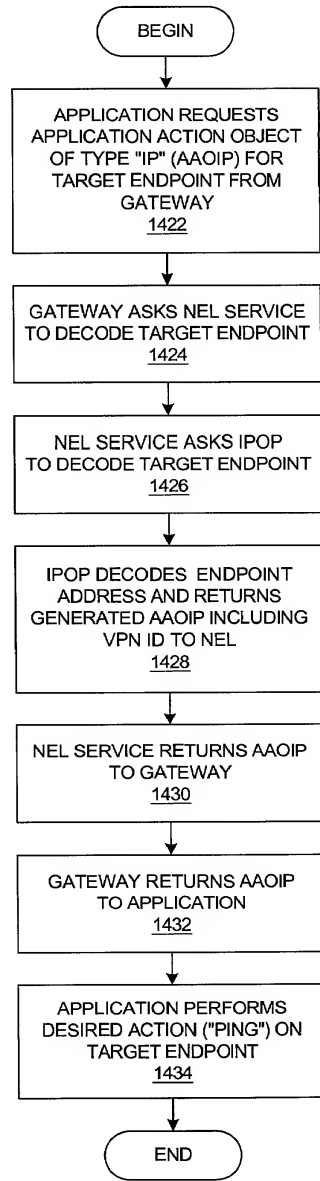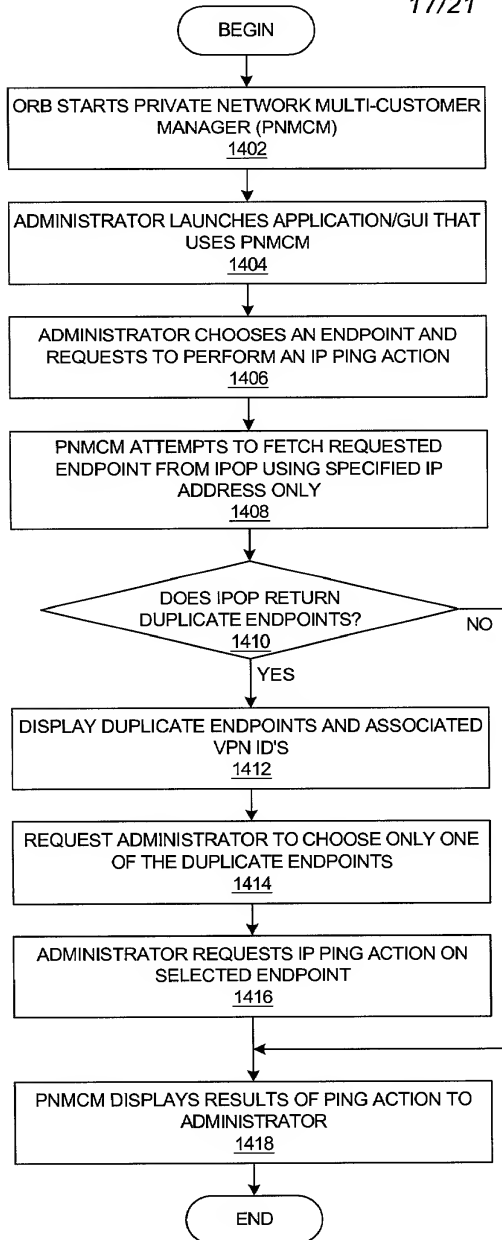
END

FIG. 14B

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```
        ┌─────────┐
        │  BEGIN  │
        └─────────┘
             │
             ▼
┌──────────────────────────────────────────────┐
│     NEW ENDPOINT DISCOVERED BY IP DRIVER       │
│                   1502                         │
└──────────────────────────────────────────────┘
             │
             ▼
┌──────────────────────────────────────────────┐
│  IP MAPPER CREATES TOPOLOGY OBJECT TO REPRESENT │
│                 NEW ENDPOINT                    │
│                   1504                          │
└──────────────────────────────────────────────┘
             │
             ▼
┌──────────────────────────────────────────────┐
│ FORM AGGREGATE RELATION BETWEEN SYSTEM IN WHICH ENDPOINT │
│          RESIDES AND ENDPOINT ITSELF            │
│                   1506                          │
└──────────────────────────────────────────────┘
             │
             ▼
┌──────────────────────────────────────────────┐
│  CREATE AGGREGATE RELATIONS BETWEEN SYSTEM AND OTHER │
│ NETWORK IF ENDPOINT RESIDES IN NETWORK THAT DIFFERS FROM │
│        OTHER ENDPOINTS IN SAME SYSTEM           │
│                   1508                          │
└──────────────────────────────────────────────┘
             │
             ▼
        SYSTEM IN
     MULTIPLE NETWORKS
    UNDER SAME ANCHOR AND ──── NO ───┐
     SYSTEM IS ROUTER?               │
          1510                       │
             │                       │
            YES                      │
             ▼                       │
┌──────────────────────────────────────────────┐  │
│    CREATE AGGREGATE RELATION BETWEEN           │  │
│        ANCHOR POINT AND NETWORK                │  │
│                   1512                         │  │
└──────────────────────────────────────────────┘  │
             │                       │
             ▼                       │
┌──────────────────────────────────────────────┐  │
│ CREATE PEER RELATIONS BETWEEN SYSTEM AND THE NETWORKS │  │
│                   1514                         │  │
└──────────────────────────────────────────────┘  │
             │◄──────────────────────┘
             ▼
        ┌─────────┐
        │   END   │
        └─────────┘
```

FIG. 15
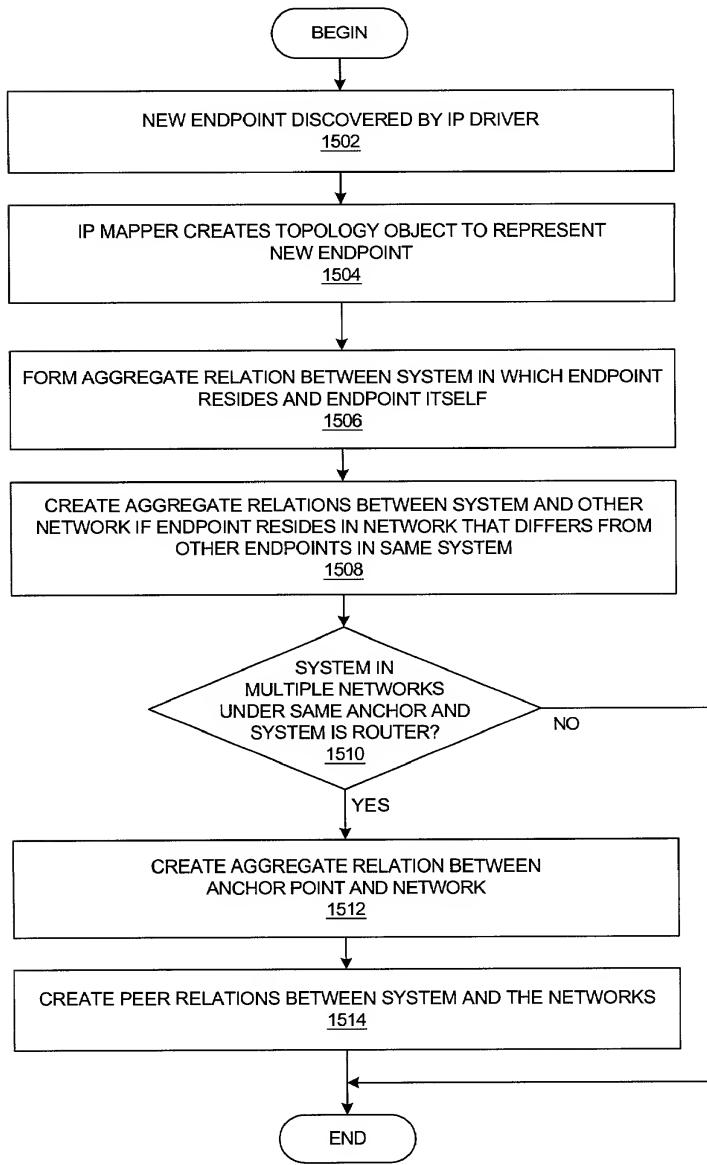
Atty. Docket # AUS920010376US1
Benfield et al.
Method and system for restricting and enhancing topology displays
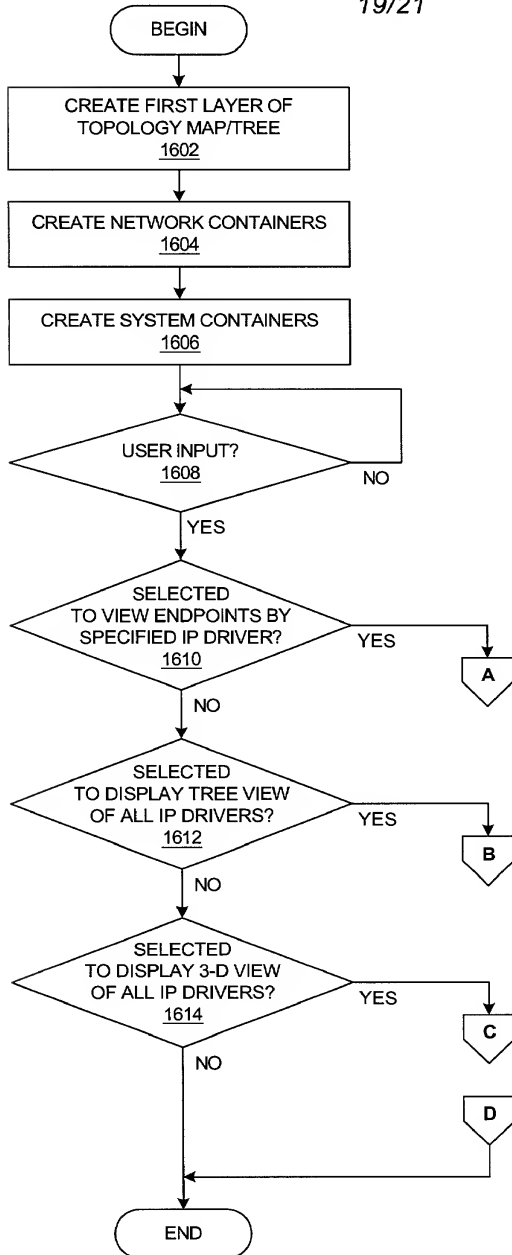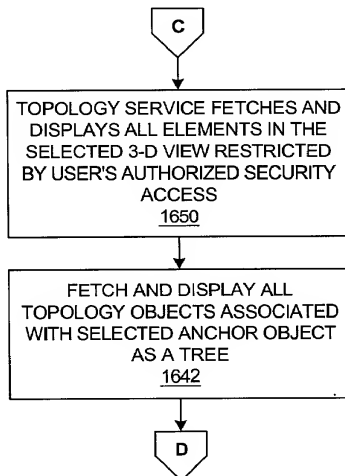**for multi-customer logical networks within a network management system**

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BEGIN

CREATE FIRST LAYER OF
TOPOLOGY MAP/TREE
1602

CREATE NETWORK CONTAINERS
1604

CREATE SYSTEM CONTAINERS
1606

USER INPUT?
1608 → NO

YES

SELECTED
TO VIEW ENDPOINTS BY
SPECIFIED IP DRIVER?
1610 → YES → A

NO

SELECTED
TO DISPLAY TREE VIEW
OF ALL IP DRIVERS?
1612 → YES → B

NO

SELECTED
TO DISPLAY 3-D VIEW
OF ALL IP DRIVERS?
1614 → YES → C

NO

D
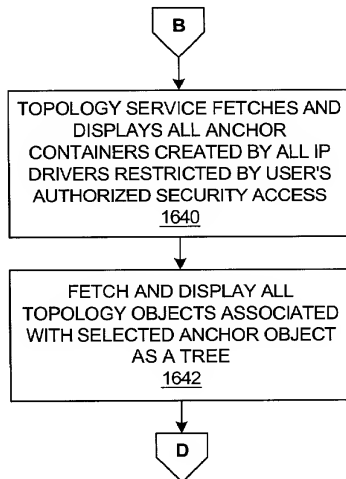
END

FIG. 16A

Atty. Docket # AUS920010376US1
Benfield et al.
Method and system for restricting and enhancing topology displays
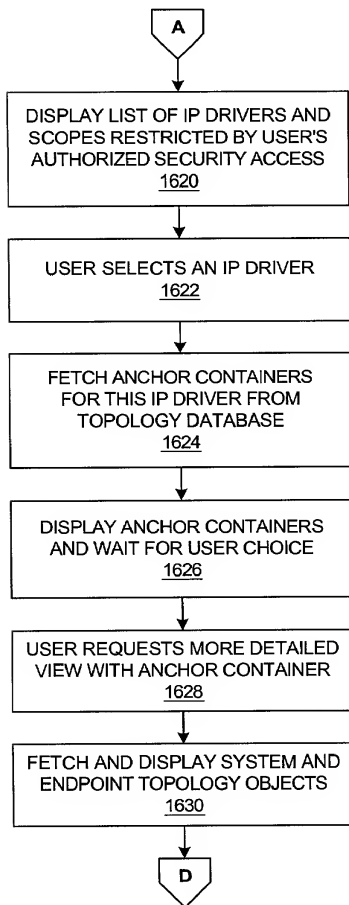for multi-customer logical networks within a network management system

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A

DISPLAY LIST OF IP DRIVERS AND
SCOPES RESTRICTED BY USER'S
AUTHORIZED SECURITY ACCESS
1620

USER SELECTS AN IP DRIVER
1622

FETCH ANCHOR CONTAINERS
FOR THIS IP DRIVER FROM
TOPOLOGY DATABASE
1624

DISPLAY ANCHOR CONTAINERS
AND WAIT FOR USER CHOICE
1626

USER REQUESTS MORE DETAILED
VIEW WITH ANCHOR CONTAINER
1628

FETCH AND DISPLAY SYSTEM AND
ENDPOINT TOPOLOGY OBJECTS
1630

D

FIG. 16B

B

TOPOLOGY SERVICE FETCHES AND
DISPLAYS ALL ANCHOR
CONTAINERS CREATED BY ALL IP
DRIVERS RESTRICTED BY USER'S
AUTHORIZED SECURITY ACCESS
1640

FETCH AND DISPLAY ALL
TOPOLOGY OBJECTS ASSOCIATED
WITH SELECTED ANCHOR OBJECT
AS A TREE
1642

D

FIG. 16C

C

TOPOLOGY SERVICE FETCHES AND
DISPLAYS ALL ELEMENTS IN THE
SELECTED 3-D VIEW RESTRICTED
BY USER'S AUTHORIZED SECURITY
ACCESS
1650

FETCH AND DISPLAY ALL
TOPOLOGY OBJECTS ASSOCIATED
WITH SELECTED ANCHOR OBJECT
AS A TREE
1642

D

FIG. 16D

Atty. Docket # AUS920010376US1
Benfield et al.
Method and system for restricting and enhancing topology displays
for multi-customer logical networks within a network management system

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BEGIN
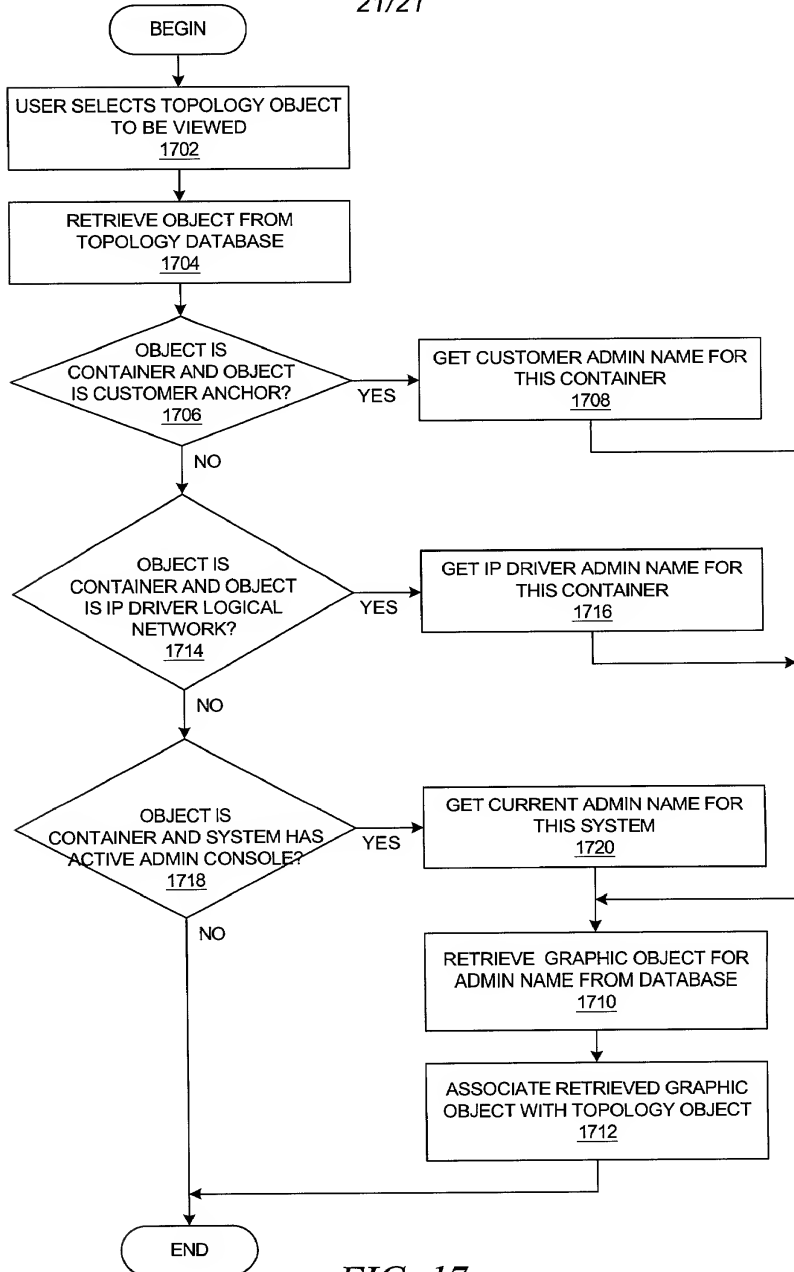
USER SELECTS TOPOLOGY OBJECT
TO BE VIEWED
1702

RETRIEVE OBJECT FROM
TOPOLOGY DATABASE
1704

OBJECT IS
CONTAINER AND OBJECT
IS CUSTOMER ANCHOR?
1706

YES → GET CUSTOMER ADMIN NAME FOR
THIS CONTAINER
1708

NO

OBJECT IS
CONTAINER AND OBJECT
IS IP DRIVER LOGICAL
NETWORK?
1714

YES → GET IP DRIVER ADMIN NAME FOR
THIS CONTAINER
1716

NO

OBJECT IS
CONTAINER AND SYSTEM HAS
ACTIVE ADMIN CONSOLE?
1718

YES → GET CURRENT ADMIN NAME FOR
THIS SYSTEM
1720

NO

RETRIEVE GRAPHIC OBJECT FOR
ADMIN NAME FROM DATABASE
1710

ASSOCIATE RETRIEVED GRAPHIC
OBJECT WITH TOPOLOGY OBJECT
1712

END

FIG. 17